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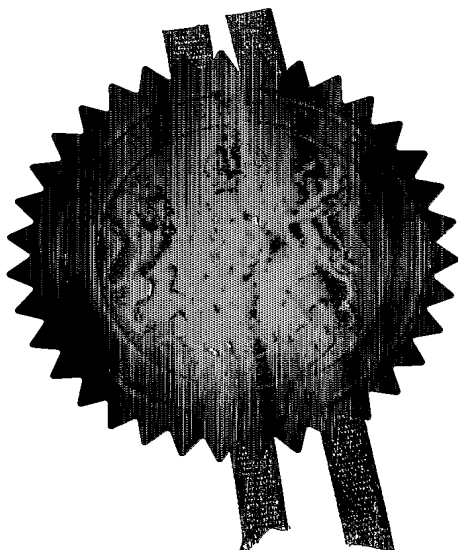
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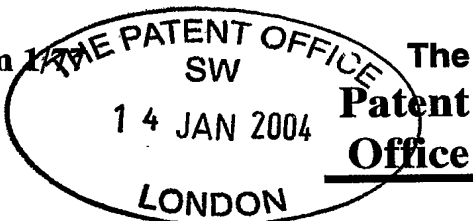
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2.	Patent application number (The Patent Office will fill in this part)	14 JAN 2004	0400808.2	
3.	Full name, address and postcode of the or of each applicant (underline all surnames)	LOTUS CARS LIMITED HETHEL NORWICH NORFOLK NR14 8EZ UNITED KINGDOM		
	Patents ADP number (if you know it)	573 9743001		
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM		
4.	Title of the invention	A TURBOCHARGED INTERNAL COMBUSTION ENGINE		
5.	Name of your agent (if you have one)	BOULT WADE TENNANT		
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Description 9

Claim(s) 4

Abstract -

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A TURBOCHARGED INTERNAL COMBUSTION ENGINE

The present invention relates to a turbocharged internal combustion engine.

5

Turbocharged internal combustion engines are well known. However, it has always been a problem to control effectively the speed of rotation of turbochargers in engines in order to control the boost applied to the intake
10 air. Wastegates have been necessary or complicated valving arrangements. Furthermore, now that it is necessary to meet strict emissions regulations for all engines, the use of high pressure turbochargers is problematic because the restrictions on flow imposed by such turbochargers and the
15 cooling of exhaust gases thereby tends to lead to unacceptable delays in catalytic converter light off. Traditionally, in engines with two-stage turbocharging it has been a problem elegantly to control the boost provided by each turbocharger in relation to the other.

20

The present invention provides a turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valves means controlling flow of air into the

25 combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of the combusted gases from the combustion chamber;

30 compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means; wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct, separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger; and

the electronic controller by controlling operation of the actuating means and thereby the opening and closing of the first and second exhaust valves is operable to control what proportion of the combusted gases leaving the cylinder flow through each of the first and second exhaust ducts.

By the use of actuators controlled by an electronic controller the operation of the exhaust valves can be controlled in such a way that the controller can control the volume and rate of flow of combusted gases through the first turbocharger and thereby control operation of the first turbocharger in an elegant way.

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows schematically a first embodiment of an internal combustion engine according to the present invention, the engine having a single stage charging system; and

Figure 2 shows a second embodiment of a turbocharged internal combustion engine according to the present invention, the engine having a two-stage charging system.

In Figure 1 there can be seen a four-cylinder engine having four cylinders 10, 11, 12 and 13. Each cylinder has an inlet valve "i" and two exhaust valves "a" and "b". The exhaust valves "a" and "b" at least are each operated by a hydraulic actuator connected to the valve. Each hydraulic actuator will be controlled by an electronic controller (not shown) which will typically be part of the engine management of the system. Each exhaust valve "a" will be opened and closed independently of the exhaust valve "b" in the same cylinder.

Combusted gases flowing from the cylinders 10, 11, 12 and 13 flow through the exhaust valves "a" to a first exhaust duct 14. This exhaust duct 14 relays the combusted gases to the turbine stage 15a of a turbocharger 15.

The exhaust valves "b" are all connected to a second exhaust duct 16 through which combusted gases can flow from the cylinders 10, 11, 12 and 13 through the exhaust valves "b" to a starter catalytic converter 17.

The combusted gases expanded in the turbine 15a are output from the turbocharger 15 via an exhaust duct 18, which is joined to the exhaust duct 16 at a joint 19. At the joint 19 the combusted gases flowing from the turbocharger 15 combine with the combusted gases flowing through the exhaust duct 16 and then the combined flow passes through a second catalytic converter 21 and then to atmosphere.

Fresh charge air is drawn into the compressor section 15b of the turbocharger 15 and is then relayed via an intake passage 19 to the intake valves "i" of the cylinders 10, 11, 12 and 13, the charge air passing through an intercooler 20 on its way to the cylinders.

The electronic controller can use its control of the actuators to control the opening and closing of the exhaust valves "a" and "b" to control what proportion of the total combusted gases flowing from each cylinder flow to the exhaust duct 14 and what proportion of the combusted gases flow through the exhaust duct 16. In this way the controller can control operation of the turbocharger 15.

When greater boost is required then a greater proportion of the total combusted gases expelled from the cylinders 10, 11, 12 and 13 is fed through the turbocharger 15 and vice versa. On start-up of the engine the majority of the combusted gases expelled from the cylinders 10, 11, 12 and 13 (if not the totality of the combusted gases expelled) will pass through the exhaust duct 16 in order to ensure an early light off of the starter catalytic converter 17 and therefore reduce the emissions on engine start-up.

In Figure 2 a second variant of engine according to the present invention is shown. This engine has four cylinders 100, 101, 102 and 103, each cylinder having an intake valve "i", an exhaust valve "a" and an exhaust valve "b". The exhaust valves "a" and "b" at least are operated by hydraulic actuators under the control of an electronic controller (not shown). Each exhaust valve "a" can be operated independently from the exhaust valve "b" in the same cylinder.

The exhaust valves "a" of the cylinders 100, 101, 102 and 103 are all connected to a first exhaust duct 104 which leads the combusted gases to the turbine part 105a of a high pressure turbocharger 105. The exhaust valves "b" of the cylinders 100, 101, 102 and 103 are all connected to an exhaust duct 106 through which the combusted gases flow to a turbine section 107a of a low pressure turbocharger 107, bypassing the high pressure turbocharger 105.

Expanded combusted gases exiting the turbine part 105a of the turbocharger 105 flow via an exhaust duct 108 to a joint 109 where the expanded combusted gases are fed into the flow of combusted gases passing along the exhaust duct 106. It is the combined flow of the combusted gases passing directly from the exhaust valves "b" and the combusted gases exiting the turbocharger 105 which are then fed to the turbine 107a of the low pressure turbocharger 107.

The combusted gases exiting the turbine 107a of the turbocharger 107 pass through an exhaust passage 110 to atmosphere via a catalytic converter 111.

Charge air drawn into the compressor part 107b of the turbocharger 107 is expelled through an intake duct 112 to be passed through an intercooler 113. The compressed air, once cooled in the intercooler 113 can then pass either
5 through the compressor part 105b of the high pressure turbocharger 105 or can pass along a bypass passage 114, bypassing the turbocharger 105 completely.

The compressed air supplied to the turbocharger 105
10 will be supplied at a first pressure and will then be pressurised to a higher second pressure by the turbocharger 105. The pressurised air leaving the compressor 105a passes through a duct 115 to be recombined with air flowing through the bypass passage 114. The combined air flow then passes
15 through an intercooler 116 and an intake duct 117 to the intake valves "i".

A bypass valve 118 is provided in the bypass passage 114. The bypass valve 118 is be controlled by the
20 electronic controller. Operation of the bypass valve 118 will enable the electronic controller to control how much of the intake air passes through the high pressure turbocharger 105.

25 The electronic controller controls opening and closing of the exhaust valves "a" and "b" (through which control of the actuators connected to the exhaust valves) in order to control what proportion of the total flow of combusted gases from the cylinders 100, 101, 102 and 103 flow through the
30 exhaust duct 104 and what proportion of the combusted gases flow through the exhaust duct 106. In this way, the

electronic controller can control operation of the turbochargers 105 and 107.

In certain circumstances it will be preferable that all
5 or at least the majority of the flow of combusted gases
bypasses the turbocharger 105 completely. In this
circumstance, the exhaust valves "a" are kept totally (or
mostly) closed and the exhaust valves "b" are opened and
closed on their own in each cycle. In this circumstance the
10 electronic controller will also open fully the bypass valve
118 so that charge air does not pass through the
turbocharger 105. For instance it is desirable on start-up
of the engine to bypass the turbocharger 105 completely.
Since the turbocharger 105 is a high pressure turbocharger,
15 it will provide a large restriction on the flow of combusted
gases from the cylinders. This restriction and the resultant
cooling of the combusted gases will increase the time to
light off of the catalyst 111. On the other hand, the low
pressure turbocharger 107 will place far less a restriction
20 on the combusted gases and therefore it is preferable that
at start up conditions the combusted gases flow only through
the turbocharger 107.

The system described in Figure 2 removes the need for a
25 waste gate which is, by its very nature, wasteful. In the
Figure 2 arrangement all the combusted gases pass through
the turbine 107.

The level of boost provided to the intake air supplied
30 to the intake valves "i" can easily be controlled by
electronic controller by varying the valve timing of the
exhaust valves "a" and "b" in order to control the gas flow

through the exhaust duct 104. Also, the controller can control boost by controlling the bypass valve 118.

5 The low pressure turbocharger 107 will be a
turbocharger with a large turbine, giving a resistance to
the flow of combusted gases much less than the high pressure
turbocharger 105, which has a smaller turbine. However, the
larger turbine size of the low pressure turbocharger 107 can
lead to throttle response problems which are particularly
10 problematic in the use of the engine in an automobile. This
problem is ameliorated by the present invention by the
electronic controller recognising times of acceleration of
the engine and in such times diverting the majority of the
flow of combusted gases to the high pressure turbocharger
15 105 which will react quickly when the throttle of the engine
is open. Obviously, the bypass valve 118 is closed in such
circumstances, in order that the intake air received by the
inlet valves "i" is boosted to its maximum.

20 At high engine speeds the high pressure turbocharger
105 could provide an excess of boost if not suitably
controlled by the electronic controller controlling the flow
of combusted gases through the exhaust duct 104 and the flow
of intake air through the bypass passage 114. Typically at
25 full loads and high engine speeds in steady state conditions
the high pressure turbocharger 105 will be in the main
bypassed so that the majority of intake air will flow in the
bypass passage 114 and the majority of combusted gas flow
will be through the exhaust duct 106.

30

The engines described above are four-cylinder
reciprocating piston engines, which could be operated either

with spark ignition or with compression ignition. However,
the invention is equally applicable to reciprocating piston
engines with any number of cylinders and furthermore is
applicable to internal combustion engines other than
5 reciprocating piston engines (e.g. rotary engines).

The exhaust valves "a" and "b" described above will be
poppet valves operated by hydraulic actuators. However, the
poppet valves could be operated by any other suitable form
10 of actuator, e.g. electromagnetic actuators. Indeed the
poppet valves could be replaced by sleeve valves or any
other suitable valving arrangement controllable by actuator.

The inlet valves "i" described above would preferably
15 themselves be controlled by actuators under the control of
the electronic controller but this is not necessary and any
form of operation of the valves could be used, e.g.
conventional cam and tappet operation.

20 In the embodiments described above only one inlet valve
"i" is provided per cylinder, but preferably two inlet
valves "i" would be provided per cylinder.

CLAIMS

1. A turbocharged internal combustion engine comprising:
 - a variable volume combustion chamber;
 - 5 inlet valve means controlling flow of air into the combustion chamber;
 - fuel delivery means for delivering fuel into the air to be mixed therewith;
 - exhaust valve means for controlling flow of combusted
 - 10 gases from the combustion chamber;
 - compressor means for compressing the air prior to admission of the air into the combustion chamber;
 - actuator means for opening and closing the exhaust valve means; and
 - 15 an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means, wherein:
 - the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least
 - 20 a second exhaust valve connected to a second exhaust duct separate and independent from the first exhaust duct;
 - the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first
 - 25 exhaust duct drive the first turbocharger to rotate;
 - the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger; and
 - 30 the electronic controller by controlling operation of the actuator means and thereby the opening and closing of the first and second exhaust valves is operable to control

what proportion of the combusted gases leaving the cylinder flow through each of the first and second exhaust ducts.

2. A turbocharged internal combustion engine as claimed in
5 claim 1 wherein combusted gases leaving the first
turbocharger after expansion in a turbine of the first
turbocharger are combined at a junction with the combusted
gases flowing in the second exhaust duct and then the
combined flow of combusted gases flow through a first
10 catalytic converter and then to atmosphere.

3. A turbocharged internal combustion engine as claimed in
claim 2 comprising additionally a second catalytic converter
provided in the second exhaust duct upstream of the junction
15 at which combusted gases in the second exhaust duct are
combined with combusted gases leaving the first
turbocharger.

4. A turbocharged internal combustion engine as claimed in
20 claim 3 wherein on starting of the engine the controller
controls opening and closing of the first and second exhaust
valves so that all or at least a majority of the combusted
gases leaving the cylinder pass through the second exhaust
duct and therefore the second catalytic converter.

25

5. A turbocharged internal combustion engine as claimed in
any one of claims 1 to 4 comprising additionally an
intercooler for cooling compressed air flowing from the
turbocharger to the cylinder.

30

6. A turbocharged internal combustion engine as claimed in
claim 1 wherein:

the compressor means comprises additionally a second turbocharger;

the first turbocharger is a high pressure turbocharger which can receive compressed air at a first pressure from
5 the second turbocharger, which is a low pressure turbocharger, and the first turbocharger compresses the air to a second higher pressure; and

combusted gases leaving the first turbocharger after expansion in a turbine thereof are combined with the
10 combusted gases flowing in the second exhaust duct and then the combined flow of combusted gases drive the second turbocharger to rotate.

7. A turbocharged internal combustion engine as claimed in
15 claim 6 wherein combusted gases leaving the second turbocharger flow through a catalytic converter and then to atmosphere.

8. A turbocharged internal combustion engine as claimed in
20 claim 6 or claim 7 comprising additionally a first intercooler through which air compressed in the second low pressure turbocharger passes before reaching the first high pressure turbocharger.

25 9. A turbocharged internal combustion engine as claimed in any one of claims 6 to 8 comprising additionally an intake air bypass passage through which air compressed by the second turbocharger can flow to the intake valve means
bypassing the first turbocharger and bypass valve means
30 controlling flow of the compressed air through the bypass passage.

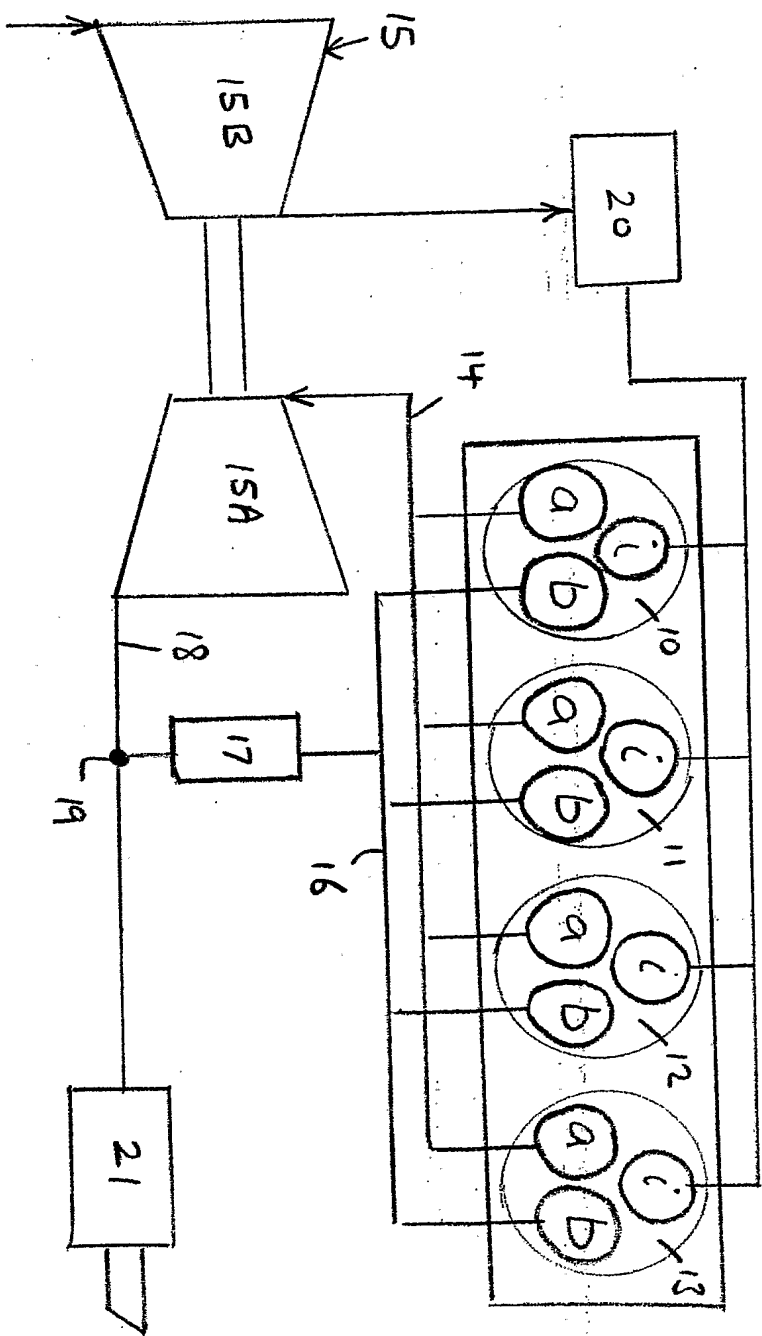
10. A turbocharged internal combustion engine substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

5

#516951 v1 - LOTUS BWT 169 spec -Turbocharger



FIG 1



1/2



FIG 2

